FAIRCONDITIONING

BUILDING ENERGY MODELLING AND ADVISORY (BEMAP) WORKSHOP REPORT

Mumbai, August 2015

Abstract

The Fairconditioning Program conducted a workshop on cooling interiors efficiently and sustainably at the Kamla Raheja Vidyanidhi Institute of Architecture, Mumbai between the 21st to 23rd of August, 2015. This report provides a basic detailed overview about the Building Energy Modelling and Advisory Program (BEMAP) and gives a detailed account of the workshop held in Mumbai.

Table of Contents

List Of Tables:

Executive Summary

The Indo-Swiss *Fairconditioning* programme organised its practitioner training "Modelling Sustainability – Training Practitioners in Building Energy Modelling for Efficient Design and Sustainable Cooling Technologies". These trainings took place from August 21 to 24 at the Kamla Raheja Vidyanidhi Institute for Architecture (KRVIA).

13 practitioners in the field of architecture attended the KRVIA, Mumbai workshop from 11 different firms from Mumbai, Maharashtra. 3 trainers conducted the workshop over a period of three days, through the mediums of lectures and hands-on software training. The Fairconditioning Programme provided certificates to all the participants.

The trainings are part of the Fairconditioning programme designed to significantly improve awareness, knowledge and know-how in today's architectural practices in the field of building energy efficiency.

Similar training workshops will be organized and targeted towards architecture and engineering colleges/universities across the cities of Pune, New Delhi, Chennai, Jaipur and Bangalore, over the course of the next two years.

The end goal is to see energy efficiency being seamlessly integrated in the core design processes of architectural practice and to equip the realm of Indian architecture with Principal and Senior architects that are ready to shoulder responsibility in India's quest for an energy efficient, sustainable building growth. They further also aim to provide a linkage between the sustainable energy industry and students or academia.

Providing additional funding, trainings will be extended to Hyderabad and Ahmedabad.

Udeet Methala
Project Manager- Building Energy Modelling and Advisory Project
<udeet@cbalance.in> T. +91-9594264328, +91-8806914128
www.fairconditioning.org

1. Introduction

Buildings consume 33% of the total energy in India and this number is growing at 8% per annum. It is estimated that 70% of the building stock that will come up by 2030 in the country is yet to to be built [1]. The cooling and refrigeration sectors are the main drivers of energy demand in India. Choosing the business-as-usual path of development would lock India in a model of energy wastage and GHG emissions on a dramatic scale, mainly in the form of buildings designed with no attention to subsequent energy consumption levels.

Fairconditioning was devised by Noe21 (Geneva) and cBalance Solutions Hub (Pune) to help countries in the tropical regions of the world address their cooling demand with the highest level of energy efficiency and lowest carbon emissions. The Pilot phase completed in June 2013 which concentrated on phasing out air conditioners using synthetic (fluorinated) refrigerants with very high global warming potential and phasing in energy efficient ACs charged with low global warming potential natural refrigerants (propane).

In its present mature phase Fairconditioning concentrates on incubating a culture of energy efficiency in the cooling of interiors in India, implying academia, large corporations and practitioners in the building services area.

Fairconditioning deploys four Projects to promote these objectives, each targeted at intervention groups who influence the perception of energy efficient technology and consumption patterns of a wide range of Indian industries and consumers:

1. Academic Curricula Integration Project - ACIP
2. Technology Adoption Project - TAP
3. Building Energy Modelling and Advisory Project - BEMAP
4. Corporate Thermal Policies Project - CTPP

2. Project Overview

2.1. The Building Energy Modelling and Advisory Project (BEMAP)

Currently the workforce available in the building industry is not sufficiently trained or knowledgeable to design and implement the construction of energy efficient buildings that India so direly needs to mainstream. Most Architecture and Engineering practices today continue to create structures that are inefficient, dismally accelerating carbon emissions and energy demand at a global scale. Architects today have a remarkably low ability to perform quantitative energy analyses of the buildings they design and their prescribed cooling strategies, that are energy intensive HVAC designsCorrespondingly, HVAC engineers are insufficiently sensitized towards the imperative and expeditious need for their industry to depart from the trajectory of GHG emissions intensive and HCFC/HFC refrigerant-based technologies. They have consequently not made efforts to build technical capacity within their organizations to integrate sustainable cooling technologies as part of their spectrum of

[1] Developing an Energy Conservation Building Code Implementation Strategy in India , May 2010

engineering design and advisory services. The Building Energy Modelling and Advisory Project (BEMAP) targets two fields of practice in the building industry: architecture and HVAC engineering. BEMAP has been designed to enhance action-oriented understanding of efficient building design processes, sustainable cooling technologies and building energy modelling (BEM) software application for architects and heat load and sustainable cooling technology design for HVAC engineers. We aim to have the ambassadors of the Fairconditioning programme to be professionals well equipped with in-depth knowledge about building sciences, awareness about sustainable cooling technologies and capability to use cutting edge energy modelling software. This is to ensure that they are capable of implementing the passive cooling strategies, recommending sustainable cooling technologies and assessing their design proposals for energy efficiency.

Architects will be shown how exactly environmental factors affect a building's performance, using quantified data to design sustainable buildings, incorporating energy efficiency at every level of the design process. HVAC engineers will predict the thermal behaviour of buildings prior to their construction and propose better-suited system designs. They will also learn to simulate the energy implications in constructed buildings in their existing conditions to enable assessment and proposals for retrofitting measures.

BEMAP aims at an ambitious but realistic objective: In 3 years from now, leading architecture and HVAC engineering firms from 5 of the biggest urban areas of India (namely Pune, Mumbai, Bangalore, New Delhi and Chennai) will have deeply integrated energy efficiency in their firm's design processes, reducing carbon emissions of their building's lifetime.

2.2. Structure of the Project

The BEMAP conducts workshops of two types :(i) Certificate Programmes for Practising Architects, and (ii)Certificate Programmes for Practising HVAC Engineers. For the next three years, each of these workshops will be held in the cities of Pune, Mumbai, Delhi, Bangalore and Chennai every year. Each workshop will train 25 practitioners, representing a diverse mix of big, mid-sized and small firms, as well as a mix of firms that have already adopted sustainability principles in their design and those that haven't. These workshops are highly subsidized so that maximum number of building professionals can take advantage of the offerings.

2.2.1. Strategy

Methods of designing and building energy efficient buildings in India are widely available, but the problem lies in the implementation of these techniques to actual practice. The BEMAP workshop aims to bridge this gap by serving as a demonstration model for enabling commercial buildings in India owned by SMEs to harness the potential for improving building envelope efficiency, in new buildings as well as in the case of building retrofitting. The advisory service trains architects and engineers who will influence SME management to choose building designs and retrofits that are energy efficient as well as able to combat climate change and warming through decreased usage of air conditioning
One of the goals of BEMAP is to impress upon practitioners the urgent need to design buildings that require minimal and sustainable cooling and those that do not guzzle energy as they currently do. Through BEMAP, architects are trained to use sophisticated building energy modeling (BEM) softwares in order to integrate energy efficiency right into their early design stage. Since passive design features often are insufficient to reach indoor thermal comfort in a business environment, residual cooling demands need to be met using some form of artificial cooling. BEMAP workshops aim to equip architects and HVAC engineers

with knowledge about the latest sustainable cooling technologies that are available in the market. These technologies include air conditioners with natural refrigerants, radiant cooling, solar vapour absorption machines and variations in evaporative cooling among others. HVAC engineers are trained to effectively use softwares ('SmartEnergy' software) for simulating sustainable cooling technologies and carrying out precise heat load calculations as opposed to using thumb rules. This would curb the practice of overdesigning of HVAC systems in buildings.

A direct benefit of the workshops for the architects is the highly subsidized software licenses for the basic modules of energy modelling software, which will be available to each of the participants. Along with this, one free premium license for the BEM software (for all modules) used in the workshop will be made available to the most motivated and enthusiastic participant, determined through evaluation tests, quizzes and demonstrated enthusiasm for acquiring these skills. All participating HVAC engineers will be provided with a free 'SmartEnergy' software license that they can use for their professional practice.

It is expected that at the end of the 3-year program, India would have a new breed of driven and progressive building professionals with the capability to design climate responsive and sustainably cooled buildings.
This advisory service is a cost effective means to inspire SME procurement and management personnel to make sound environmental and economic decisions based on solid evidence for savings. A ripple effect is expected for non- participating SMEs. SMEs are specifically targeted because their energy costs considerably reduce their profitability. Unlike large corporations, SMEs do not receive subsidies and other forms of support. Further, SMEs do not have the in-house capacities and know-how to efficiently manage their energy consumption.

The eco-system building component of the project weaves the architects and HVAC professionals graduating from the training workshops, along with already qualified HVAC professionals and architects with established credentials as practitioners of energy efficient building and sustainable cooling technology design, into a vetted panel of service providers. Through Roundtables and other outreach efforts, these trained professionals are made visible to companies from the commercial sectors engaged by the Technology Adoption Program. The trained professionals will also absorb qualified and motivated interns emerging from student certification workshops (organized by Faircondtioning's Academic Curricula Integration Project) and collectively make low-cost energy modelling services available to SMEs (provision in the budget is for 160 projects).

2.2.2. Steering Committee

During the initial phase with KRVIA, Mumbai, a steering committee was constituted comprising of the professors from the specific colleges and Fairconditioning staff and select advisory board members. The Steering committee developed the specific curricula for the workshops, selected the experts on subjects to carry out the training, and defined the venue and calendar of events. These events organized by Fairconditioning bring a selection of specialised practitioners to share their knowledge with college staff and with students. Specialists are either architects, consultants specialised in assisting architects with energy related issues, engineers specialised in indoor cooling, etc. They are selected by the Steering Committee for their knowledge as well as their capacity to share their passion in a pedagogically effective manner.

3. Workshop Proceedings

3.1. Workshop Plan

A suitable venue, usually a renowned architecture or engineering college is selected for each BEMAP workshop. The venue is checked for the infrastructure that would be required for successful implementation of the workshop. The computer systems that the participants train on are checked for hardware requirements needed to smoothly run simulations in the building energy modelling softwares. For the training sessions, rooms that are airy and make use of natural sunlight, as well as those that have set-ups conducive to maximum interactions between the participants and trainers are preferred. The venue for this particular workshop in Mumbai was selected accordingly. The workshop took place at Kamala Raheja Vidyanidhi Institute for Architecture and Environmental Studies (KRVIA).

3.1.1. Pre-Workshop Knowledge Dissemination

Resources that give a background of the Fairconditioning program and the details of the BEMAP program were shared with potential participants. These resources are in the form of videos, brochures and posters. A brief workshop itinerary outlining the topics covered during the 3 days as well as a detailed agenda helped participants get a good sense of what to expect in terms of training content. Furthermore, the trainers were provided with a brief, which include the guidelines, limitations and the basic agenda of the workshop to ensure that the delivery was relevant and effective.

For future workshops, the BEMAP program is also looking at the possibility of introducing the pre-requisite of completion of an online course (a Massive Online Open Course, or MOOC) that would enable the participants to have clarity in basic concepts before attending the workshop. This would help the program go beyond the basics and develop workshop content that dives deeper into theory and application.

3.1.2. Workshop Activities

The aim of the workshop was to help the architects understand the principles of sustainable cooling technologies, while merging it with building science principles for the purpose of building energy modelling. For this purpose, Day 1 consisted of theory based training on concepts and applications. The topics covered included application of heat transfer, understanding psychrometric processes, climate analysis, solar geometry fundamentals, day lighting, passive design strategies and principles and applications of sustainable cooling technologies.. The sessions were interactive and peppered with quizzes to engage the participants. Various worksheets devised as practical assignments were distributed to participants. These practical assignments done during the sessions helped the participants gain a better understanding of the concepts presented by the trainer. Day 2 and Day 3 were devoted to hands-on learning of the building energy modelling (BEM) software. The software used was IES (Integrated Environmental Solutions). During these two days, participants were able to use the concepts presented on Day 1 in creating buildings and simulating them for energy usage, carbon emissions, air flow, shading requirements, daylighting etc. The hands-on sessions provided the participants a chance to use the software themselves in order to gain confidence for usage in their professional practice. With respect to building energy modelling, understanding of how to set up geometry, assigning of weather files, shading and solar analysis, day lighting simulations using radiance, design iterations to

reduce thermal loads, ventilation analysis using Macroflo, assigning space conditioning systems, assessing the whole building performance and navigator technology, along with the IES-GAIA module were taught to the participants. Time for independent working sessions was also given to the participants.

Evaluation of what participants have been able to absorb and feedback are imperative to gain an understanding of the efficacy of the training program and make necessary changes to improvise on the training content and overall workshop organization. On Day 1, an oral assessment was carried out to have an idea of how well the participants have been able to absorb the training. On Day 3, a written as well as practical assessment was carried out. The assessment questions can be found in Annexure B. Evaluation helped the BEMAP team to recognize the best performing participant who received a free annual license of the BEM software. A feedback form was distributed to participants at the end of the workshop. This feedback form covered questions on workshop content, training methods, assessment of the participants' confidence in using the BEM software and other knowledge shared during the workshop in their respective professional practices as well as some general questions on workshop organization. The complete feedback form can be found in Annexure C.

3.1.3. Post-Workshop Follow-Up

Once the workshop is completed, there are a few immediate follow-ups that are carried out and some long-term follow-ups that the BEMAP team aims to carry out. The immediate follow-ups include the following:

- Digitizing and assessing of the feedback forms. Also absorption of oral feedback given by participants and trainers
- Assessing answers of participants in the written and practical evaluation
- Coordinating with the software company (IES in this case) to share a free annual license version to the one participant whose performance was deemed best through assessment of evaluation tests, quizzes and enthusiasm demonstrated during the entire workshop. In this particular workshop, Ms.Prakriti Shukla from the firm 'The Think Attic' was given the free software licence
- Sharing the workshop trainee kit with participants. This trainee kit contains all presentations from the workshop, BEM software tutorials, the Energy Conservation Building Code (ECBC), tip sheets created by ECBC for energy simulations and set-up files of softwares used on Day 1 for climate analysis, psychrometrics and solar geometry
- Send workshop attendance certificates to participants
- Payments to trainers, food caterers, venue rent etc.
- Assessment of notes for content upgradation and training methods made by team members during the workshop. Convey the same to the trainers and work on upgrading the content as per the notes.
- Make decisions on overall workshop management for coming workshops based on the feedback by participants, trainers and BEMAP team members
- Coordinating with participants and software company to troubleshoot issues faced by the participants during set-up and usage of BEM software in their professional practice

A long-term follow-up exercise will include checking up on participants to gauge how far they have been able to implement the learnings from the BEMAP workshop into their professional practice.

3.2. Workshop Stakeholders

3.2.1. Trainers

Two trainers conducted all training sessions in the 3-day workshop. The details of the trainers and the sessions they conducted are given in the table below:

Table 1. Details of the Trainers at the Workshop.

Trainer	Designation & Organization	Sessions Conducted
Deepa Parekh	Project Manager, Environmental Design Studios (EDS)	Buildings and Heat: Understanding Heat Flows and Forms, Psychrometrics and Climate Analysis, Solar Geometry: Studying the Sun for Better Architecture, Daylighting: Technical Terms and Benchmarks, Passive Design Techniques and Sustainable Cooling Technologies: Principles and Applications.
Anantaditya Aima	Training Consultant and Building Simulation and Analysis, IES	Set up geometry, assigning weather file, Shading and Solar analysis, Day lighting simulations using radiance, Design iterations to reduce thermal loads, Understanding the results, Ventilation analysis using Macroflo, Assigning space conditioning systems, Assessing whole building performance, Understanding results, Navigator technology and IES-GAIA module, Independent working session and assessment.

3.2.2. Trainees

Table 2. Details of the Participants attending the Workshop

S.No	Name of Participant	Firms/Colleges that the Participants Represent
1	Roshni Chand	Tushar Desai Associates

2	Priyanka Agarwal	Tushar Desai Associates
3	Tini Abraham	EDS
4	Prakriti Shukla	The Think Attic
5	Trishta Vardhan	Neelam Realtors
6	Meghna Gilani	Decode Architecture
7	Prasanjit Debnath	Sanjay Puri Architects
8	Vikram Pawar	Studio Architecture, KRVIA,
9	Kimaya Keluskar	Kimaya Architectural Studio, KRVIA
10	Abhijit Ekbote	Abhijit and Associates, KRVIA
11	George Jacob	Independent consultant, KRVIA
12	Minal Yeramshetty	Venkat Designs, KRVIA
13	Tapan Maharishi	Tapan Dharnidhar Consultants Private Ltd, KRVIA

3.2.3. Venue

This workshop was conducted at the well-known architecture college Kamala Raheja Vidyanidhi Institute for Architecture and Environmental Studies' (KRVIA) in Mumbai.

The details of the venue are as follows:
Kamla Raheja Vidyanidhi Institute for Architecture and Environmental Studies (KRVIA)
Vidyanidhi Bhawan II, Vidyanidhi Marg
J.V.P.D. Scheme, Mumbai - 400 049
Website: www.krvia.ac.in
Phone: +022-2670.0918

3.3. Workshop Outline

A workshop outline for all three days along with the detailed narrative for all sessions is given below. While day-1 was reserved for training in theory, the next two days were utilized for practical, hands-on BEM software training.

Table 3. Detailed Narrative and List of Sessions conducted during the workshop.

Day 1: Friday, 21st August, 2015	Timing: 10.00 am to 6.00 pm	
Number	Time	Title

1.0	10.00 am – 10.15 am	**Introduction to the Fairconditioning Programme**
	Session 1: Building Science-Principles and Applications	
1.1	10.15 am – 11.15 am	**Impact of Architecture on Heat Transfer** This session involves the understanding of two main topics, Principles of heat transfer and Forms of heat. Principles of heat transfer will include the modes of heat transfer, heat transfer, heat transfer in the context of buildings and the thermal properties of materials. Forms of heat include the introduction to the different forms of heat along with understanding the forms of heat in the context of buildings.
1.2	11.15 am – 12.15 pm	**Understanding Psychrometric Processes** This session includes the reading and analysing of the psychrometric chart. site
1.3	12.15 pm – 1.30 pm	**Climate Analysis** This session includes the analysing of the climate for building design, concentrating on both the theory and practice.
Break	***1.30 pm – 2.15 pm***	***Lunch***
1.4	2.15 pm – 3.15 pm	**Solar Geometry Fundamentals and Day lighting** This session involves the Sun and its movement, where in the trajectory of the sun's movement, what causes seasons and the seasonal sun paths will be discussed in detail. It also includes an analysis of the position of the sun, where in the participants will be taught how to measure the position of the sun, and will be given a brief understanding of the sun path charts for building design. It further includes the understanding of the shadow mask, which involves the concept of the shadow mask, how to generate shadow masks and how and when to provide for shading while designing a building.
1.5	3.15 pm – 4.15 pm	**Identifying Passive Design Strategies** This session involves the understanding of passive

		design techniques and the concepts related to them. It includes an introduction to passive design, where in the objectives and different approaches to passive design are discussed in detail. It further includes the understanding of thermal loads in buildings, where in the factors impacting cooling loads, the greenhouse effect, the techniques used to avoid heat absorbed are discussed. Further, the participants are taught how to use bioclimatic charts to reduce the cooling loads. The understanding of thermal comfort, where in an introduction to thermal comfort and the international and India specific thermal comfort standards are also discussed in detail. This session further looks into the case studies using passive design techniques, along with an introduction to the various performance benchmarks in buildings.
Break 2	***4.15 pm – 4.30 pm***	***Recess for the mind; Tea Break***
1.6	4.30pm – 5.30 pm	**Cooling Science and Low Energy Cooling Technologies and their Application** This session involves the understanding of the working principles, constraints and applications of the different sustainable cooling technologies. These sustainable cooling technologies include direct/indirect evaporative cooling, solar vapour absorption machines and radiant/structure cooling. Further in this session, case studies with respect to each of these cooling technologies will also be discussed in detail.
1.7	5.30pm – 6.00pm	**Assessment and Feedback**
Day 2: Saturday, 22nd August, 2015		Timing: 10:00 am to 6.00 pm
		Building Energy Modelling – Part 1 In Building Energy Modelling, a software engine computes and analyses results through the different tools provided. These tools are categorised parameters being analysed. To interpret these results and inform design decisions using quantified data, not only improves the quality, but also enables precision in a design strategy**.**
2.1	10.00 am – 11.30 am	**Set Up Geometry, Assign Weather File**

		Participants are shown how to set up location and weather files for the building site and creation of a building in the IES:VE interface
Break 1	***11.30 am - 11.45 am***	***Recess for the mind; Tea Break***
2.2	11.45 am – 1.00 pm	**Shading and Solar Analysis** This session contains the visualization and analysis of sun-paths as well as shading in buildings
Break 2	***1.00 pm – 1.45 pm***	***Lunch***
2.3	1.45 pm – 3.15 pm	**Day lighting Simulations using Radiance** In this session participants are shown how to simulate and read day-light levels in each portion of the building
Break 3	***3.15 pm – 3.30 pm***	***Recess for the mind; Tea Break***
2.4	3.30 pm – 5.00 pm	**Design iterations to reduce thermal loads** This session shows participants how thermal loads in buildings can be reduced through changes in design
2.5	5.00 pm – 5.15 pm	**Understanding Results** This session shows the participants how to interprete the simulation results
2.6	5.15 pm – 6.00 pm	**Independent Working Session** This session allows participants to independently apply their knowledge gained during the day and consult the trainer when required
Day 3: Sunday, 23rd August, 2015		Timing: 10.00 am to 6.00pm
		Building Energy Modelling – Part 2
3.1	10.00 am – 11.30 am	**Ventilation analysis using Macroflo**

		This session instructs participants how to visualize and interpret air flow in various parts of the building
Break 1	***11.30 am - 11.45 am***	***Recess for the mind; Tea Break***
3.2	11.45 am – 1.00 pm	**Assigning space conditioning systems** In this session participants are shown how to correctly assign various air conditioning systems in the spaces of the building designed.
Break 2	***1.00 pm – 1.45 pm***	***Fuel Up (Lunch, Walk, Breathe)***
3.3	1.45 pm – 3.15 pm	**Assess whole building performance** Participants are shown the various aspects of assessing the whole building performance and correctly reading simulation results
Break 3	***3.15 pm – 3.30 pm***	***Recess for the mind; Tea Break***
3.4	3.30 pm – 4.15 pm	**Understanding Results**
3.5	4:15 pm – 5.00 pm	**Navigator Technology and IES-GAIA module** The IES-Gaia module and the navigator technology is a new addition in the IES:VE interface. It is designed to help architects undertake a detailed step-by-step structured workflow, which streamlines the process of simulation and ensures no step is missed.
3.6	5.00 pm – 6.00 pm	**Independent Working Session, Assessment and Feedback**

The BEMAP workshops are intended to be a low-carbon as possible. With regards to this, the following measures have been introduced for all workshops. These measures were also kept in mind for this particular workshop and all efforts were made to see that they were implemented.

- Recycled, low-embodied energy stationary
- No packaged drinking water
- Double-Sided / Recycled paper printing

- No disposable utensils, cutlery
- Casual dress code & 24 degree minimum AC setting
- Natural light & ventilation use
- Discouraging air travel, Encouraging train travel between cities
- Encouraging public, non-motorized transport within city
- Low-EPI hotels (2/3 Star) for team and trainers
- Socially Inclusive Carbon Offsetting of Carbon Footprint (Afforestation Projects)

3.4. Workshop Outcomes

3.4.1. Overall Learnings for Project Enhancement

Capacity building of project team: By conducting the Pune and Mumbai workshops for architects, the Fairconditioning programme, has completed 'pilots' and absorbed key learnings from these two events. In addition, the capacity of the project team has been built substantially, due to exposure to the training content and its review, engagement with the trainers and aiding the training process during exercises, and hands-on software use. This capacity building helped institutionalise this knowledge, homogenise training content, improve the quality of content and develop strategies to streamline content delivery for the future workshops.

Skepticism alleviation and more effective outreach to potential participants required: Approached by the BEMAP team, the principal and senior architects in Mumbai showed largely negative responses to the programme's goal with respect to the implementation of the learning into design practice. While most architects showed resistance or dis-interest in sustainability and incorporating additional software and related skills, only a small fraction of them were willing to engage in a discussion about the possible value in being exposed to sustainability concepts. Among these architects, a small number of architects agreed to participate after convincing them through a range of different approaches. The main concern for architects was that the construction industry that their clients came from does not include energy efficiency as an enforced requirement. Financial implications on the architecture firm for implementing such processes of along-with design analysis in the conventional design process were also seen to be unviable, as the architect would need to absorb these costs. The absence of general awareness in their field and among clients was cited as the main reason for their scepticism toward such a programme
A plan to alleviate scepticism regarding the program and its benefits needs to be put in place. Outreach to potential participants needs to be greatly increased through multiple platforms and networks.

Pioneering partners: Each of the architects trained in the workshops accepted their role as early adopters of the sustainable approach to building design and recognised its need as imperative. While some degree of scepticism in their ability to implement remained, they were resolved to increase awareness and attempt implementation in their individual capacities within the firms they represented.

Identification/knowledge of latest software's: During the training presentations several exercises, rules of thumb and latest software's were explored, demonstrated and used. The architects felt more aware and confident in using BEM, applying passive design strategies and proposing the use of sustainable cooling technologies. The extensive exposure to modern, state of the art software IES:VE was a unique experience to most trainees.

Follow up plan with participant architects: Post the events, participant architects were provided with all trainer presentations, exercises, tip-sheets, step-wise instructions for download, installation activation and tutorials in-order to use the BEM software on computer systems at the firm. Participants were also provided references, internet links and reading material to strengthen their new learning and improve their awareness on the subject of energy efficiency in building design.

3.4.2. Specific Learnings by the BEMAP Team

- Strategize to make sure that last-minute participant drop-out rate is as low as possible. Send reminder e-mails and SMS the day before the workshop
- Strategize to make sure that the participants reach the venue on time and sessions on each day begin at the pre-designated time. This would ensure that all content is covered smoothly.
- Develop a 'Convincing Builders' session for the architects. This is to address the common concern by architects that it is a tough task to convince builders to use sustainable building design and explore options to utilize sustainable cooling technologies due to relatively higher capital cost.
- For each module on Day 1, a context needs to be added in the beginning which explains how it would be useful for architectural practice.
- More graphics, illustrations, diagrams, animations to be used to explain concepts
- Need to address the common complaint of participants of information overload by the time the workshop enters its third day.

3.5. Feedback Summary

3.5.1. Oral Feedback

Participants were happy with the content covered on all three workshop days. Some participants expressed that such workshops were greatly required to generate interest and knowledge in energy efficient building designs.

The module on sustainable cooling technologies especially generated the interest of participants and none of them had been exposed to these technologies before.

Many participants believed that one of the major hindrances towards the adoption of BEM softwares was the lack of exposure to their user interface, especially for the building geometry. Problems with importing from more widely used softwares like Autocad, Google Sketch-Up etc. compounds the problem. Participants felt that this could be resolved by introducing the user interface of these BEM softwares at the college-level for architecture students.

3.5.2. Written Feedback

- About 50% participants believed that the content of the training matched the objectives of the program.
- All the participants agreed that the trainers made good use of the time allotted to them, and they seemed knowledgeable about their concerned topics. They also believed that the sessions on all three days were well explained.
- Most of the participants agreed that they understood the concepts presented in the workshop, and the practical application of it. Some of the participants found the using

of certain softwares to be a little difficult, but when spent enough time on it, they were able to use it properly.

- Most of the participants agreed that the theory sessions enhanced their understanding of the BEM software.
- Most of the participants pointed out that adequate information on the workshop objectives and content was not provided prior to the workshop.
- Most of the participants pointed out that the length of the workshop should be increased.
- More than half of the participants felt that they would recommend this workshop to others, and also stated that they enjoyed the workshop

4. Annexure

A. Photographs:

Figure 1. Day 1 of the BEMAP workshop.

Figure 2. Deepa conducting one of the sessions on Day 1.

Figure 3. Participants working on the psychrometric chart exercises.

Figure 4. Participants using the building modelling software on Day 2.

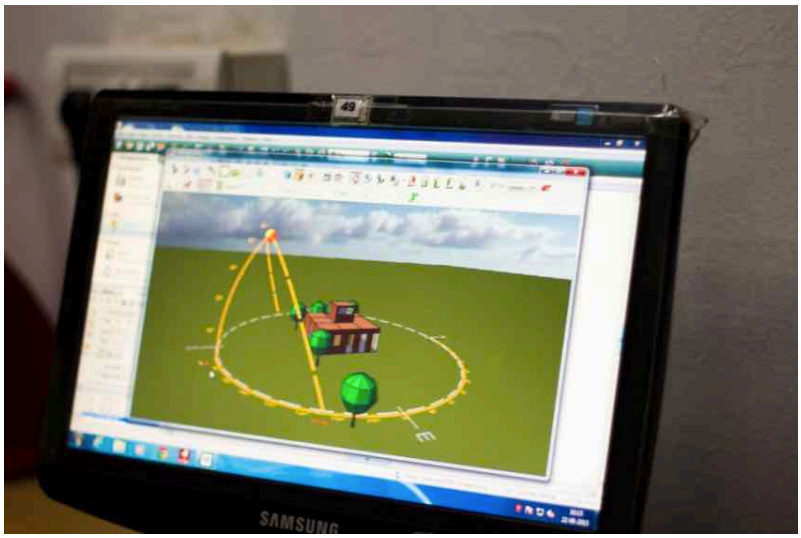

Figure 5. An image of the model built by one of the participants.

B. Evaluation Forms:

1. Fairconditioning Evaluation Quiz (Day 1 – Oral Evaluation)

SUSTAINABLE COOLING

TOOLS AND TECHNIQUES FOR ARCHITECTS

Roadmap for passive design and low energy cooling

This worksheet is developed to become a reference document for passive design process. Please use this to add your notes during the workshop to populate the key information for future reference. This is also a worksheet that you will be using during the program to understand the application of concepts in design.

Building Heat Transfer Fundamentals

- Key points:
  a. Buildings lose and again heat through conduction, convections and radiation
  b. There are three forms of heat – sensible, latent and radiant heat
  c. Building design should address “thermal loads”. This can be done by designing in response to climate and sun. Reducing thermal loads through passive design is fundamental to achieving energy efficiency.
  d. Properties of materials that affect
     i. Conduction
     ii. Convection
     iii. Radiation

- Notes:

Quiz:

1. Sensible heat results in increase in temperature of objects

2. All objects emit radiation irrespective of the temperature:
   a. True
   b. False

3.Dense objects can hold more sensible heat:

a. True
b. False

4. Energy is released when water freezes to ice:

a. True

b. False

5. Latent heat results in rise in temperature of the objects:

a. True
b. False

6. Radiation heat transfer can occur in vacuum:

a. True
b. False

7. Heat is always transferred from a warmer object to a cooler one, irrespective of the mode of heat transfer:

a. True
b. False

8. The “greenhouse effect” is of concern because:

a. It may block incoming solar radiation and lead to a cooling of the Earth
b. It may block incoming solar radiation and make solar collectors ineffective
c. It may cause such serious air pollution problems that our health is affected
d. It may trap incoming solar radiation and lead to a warming of the Earth

9. Which of the following has high thermal mass?

a. Masonry
b. Glass curtain wall
c. Water
d. All of the above

10. Material A has a conductivity of 200 W/m C and material B has a conductivity of 150 W/m C. Which of these is a good conductor?

a. Material A
b. Material B

11. U-value accounts for sensible heat flow only:

a. True
b. False

12. Wall A has a R-value of 2.5 sqm.K/W and Wall B has a R-value of 4 sqm.K/W. Which wall would you recommend for improving energy efficiency?

a. Wall A
b. Wall B

2. IES Evaluation Form (Day 3)

IES PRACTICAL ASSESSMENTOR MUMBAI ARCHITECT WORKSHOP

Please read the following data to design, model and analyse your building design.
Time: 45 minutes

OBJECTIVES:
Lower Energy Consumption,
Lower Unmet Hours (Ideal Room temperature is $> 18^{o}$ and $< 27^{o}$)

GIVEN

Date: 21st March

Location: New Delhi

Height: 4 Storey 3 metres each

Footprint Area: 400 mt^2

Lighting power Density/ Sensible gain- 10 W/sqmt
Occupancy 10 sqmt/ person – Default Heat gains (9 am to 6 pm)
Air -conditioning to be provided from : 9 am to 6 pm.

SUGGESTED STRATEGIES

Natural Ventilation

Shading

Material choice

Daylight levels of min 250 lux for 70 % area on Working Plane.

No renewable energy allowed on site. No trees.

3. Fairconditioning Evaluation Quiz (Day 3)

SUSTAINABLE COOLING

TOOLS AND TECHNIQUES FOR ARCHITECTS

---

1. Thermal mass provides all of the following except:

   a. Time lag
   b. Heat capacity
   c. Thermal inertia
   d. Thermal insulation

2. 'Transmissivity' affects the sensible heat gained by a material through radiation:

   a. True
   b. False

3. What is the range of values for the emissivity of a surface?

   a. -1 to 1
   b. 0 to 5
   c. 1 to 10
   d. 0 to 1

4. List at least three characteristics of energy efficient buildings

5. Horizontal overhangs as shading devices are best suited for which direction?

   a. North
   b. South
   c. East
   d. West

6. Which is the cooler side of a vapour compression system?

   a. Evaporator
   b. Condensor
   c. Compressor

7. In absorption refrigeration systems, the compressor vapour compression systems is replaced by:

   a. Absorber
   b. Generator
   c. Pump
   d. All of the above

8. Solar energy based refrigeration systems are developed to:

   a. Reduce fossil fuel consumption

b. Provide refrigeration in remote areas
c. Produce extremely low temperatures
d. Eliminate compressors

9. Human beings need air conditioning because:

a. They continuously dissipate heat due to metabolic activity
b. Body regulatory mechanisms need stable internal temperatures
c. Efficiency improves under controlled conditions
d. All of the above

10. Small residences and offices use:

a. Window air conditioners
b. Split air conditioners
c. Central air conditioning
d. All of the above

C. Feedback Form:

fAIR CONDITIONING

FEEDBACK FORM

Thank you for taking the time to write your honest responses to the questions in this feedback form.
Your feedback will help us design better workshops in the future.

Please enter your response by shading the circles representing the following:

(1=Strongly Disagree, 2=Disagree, 3=Neutral, 4= Agree, 5= Strongly Agree)

Workshop Content and Training Methods

1) The content of the training matched the objectives

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

2) The trainers made good use of the time allotted:

a) Deepa Parekh

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

b) Anantaditya Aima

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

3) The trainers seemed knowledgeable about their topics:

a)Deepa Parekh

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

b)Anantaditya Aima

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

4) I understood the concepts as presented in the workshop

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

5) I understood the practical application of the concepts presented

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

6) The theory sessions enhanced my understanding of the BEM software

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

7) Day1: The Session 'Building Science-Passive Cooling-Benchmarking-Energy Modelling' was well explained

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

8) Day2: The session 'Building Energy Modelling-Part 1' was well explained

1 2 3 4 5
Strongly Disagree ○ ○ ○ ○ ○ **Strongly Agree**

9) Day3: The session 'Building Energy Modelling-Part 2' was well explained

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

Workshop Impact

1) I feel it is of vital importance to design energy efficient buildings

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

2) The knowledge and skills I learned from the workshop will be useful in my job

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

3) I feel confident in using the BEM software effectively for the design processes at my workplace

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

4) I feel using the BEM software in my work will effectively help in designing more energy efficient buildings

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

5) The workshop made me want to learn more on efficient cooling and its implementation

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

General

1) Adequate information on workshop objectives and content was provided prior to the workshop

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

2) The length of the workshop should be increased

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

3) The length of the workshop should be shortened

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

4) The overall time-management during the workshop was appropriate

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

5) I would recommend this workshop to others

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

6) I enjoyed the workshop

1 2 3 4 5
Strongly Disagree O O O O O **Strongly Agree**

Other Comments: